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DIRECT WET SEEDING AS AN ALTERNATIVE TO TRANSPLANTED RICE (*ORYZA SATIVA*) CULTIVATION IN ANDAMAN & NICOBAR ISLANDS

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ABSTRACT

Field experiment was conducted in split plot design with five replications during 2015 *kharif* season at ICAR-CIARI, Port Blair, Andaman & Nicobar Islands, India. Main plot consisted of two establishment methods i.e. direct wet seeded rice (DWSR) and Transplanted rice (TPR) and sub plot consisted of four rice cultivars (Swarna, BPT-5204, CARI Dhan-6 varieties and US-312, a hybrid). The results revealed that DWSR crop maturing 12.2 days earlier with 52.9% higher panicle density (367.5/m^2) but 24.8% lesser grains/panicle (103.8) has produced 0.47 and 2.08 t/ha higher grain and biological yield than TPR (3.81 and 8.68 t/ ha). The reduced cost of production (Rs. 10, 203/ha) on account of lower man power use (20 man days) together with higher yields in DWSR have resulted in 2.76 times more net income than TPR (Rs. 11,068/ha). Energy, fertilizer, rain water and per day productivity of DWSR were perceptibly higher than TPR. Among cultivars, Swarna (4.52 t/ha) on an average has 0.72 t/ha and 15,094 Rs/ha higher grain yield and net income than other three cultivars. Interaction effects indicate that DWSR is best for varieties and hybrid has similar performance under both establishment methods. The study establishes DWSR as economically promising to TPR.

INTRODUCTION

Rice (*Oryza sativa* L.) is the sole staple grown in Andaman & Nicobar Islands (ANI) as a rainfed transplanted *kharif* crop of lowlands. During 2017-18, it was cultivated on 5340 ha area producing 16,845 tonnes (t) of paddy at an average productivity of 3.16 t/ha (DOES, 2017-18). Transplanted rice (TPR) cultivation adopted widely in labour surplus Asian countries was the best establishment method (Mohanty *et al.*, 2017). It is estimated that 850-900 man-hours of labour/ha was required for TPR culture (Singh *et al.*, 2013); of which transplanting alone accounts for 25% of man hours of labour (Swain *et al.*, 2013). Man power for agriculture is becoming costly year after year in the country due to creation of greater employment opportunities in the industry and service sectors with higher wages resulting in migration of man power from rural to urban areas. Further, the implementation of Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) has also reduced the labour availability for agriculture besides increasing their wages exorbitantly. The tedious transplanted operations of rice were not preferred by labour and demands higher wages than other field operations. These ever escalating labour costs are eroding the profit margins of TPR culture and sometimes losses are also realized by farmers. Non-implementation of minimum support price in ANI is further deteriorating the profits from the rice crop. In context of unfavourable economics, farmers are keeping their lands either fallow or switching to alternate crops where ever possible. This was evident from the fact that rice area has decreased from the peak 12,000 ha in mid 1990s to the current 5340 ha. Further, South Andaman district, the hub of rice cultivation prior to 2004 tsunami close to Islands capital, Port Blair has lost its acreage completely due to its urban nature (more employment opportunities in service and industry to labour) and the same was picked up in rural North & Middle Andaman district situated at > 100 km away from Port Blair due to comparatively cheaper labour (DOES, 2017-18) and accounts for 96.5% area and production now. This was true for all other rice growing areas of the India and Asia too. To tide over these problems of TPR culture, the concept of direct wet seeding of rice (DWSR) in puddled soils has been evolved. The utility of DWSR in reducing production costs by 40%, increasing productivity and profits by 8 and 56% in Godavari district of Andhra Pradesh (Martin Gipmans *et al.*, 2016) as compared to TPR shows the technologies potential. Of course, there are challenges with DWSR like intense weed pressures (Chauhan and Johnson, 2010) which have been addressed through use of suitable new herbicides (Chongtham *et al.*, 2016) including the adoption brown manuring (Gangaiah and Prasad Babu, 2016) with twin benefits of N nutrition and weed management. There are reports of water economy with DWSR (Raguveer Rao, 2012), however, the need for having perfect control over water during initial stages of germination and establishment also poses a challenge that is also being addressed through proper land levelling and drainage channels establishment etc. In the above context of emergence of DWSR as a viable alternative to TPR, there is need to evaluate this technology in Islands too. Hence, the present study was made to ascertain the utility of DWSR and identify suitable medium duration high yielding cultivars for

ANI for making the rice cultivation more profitable and take stakeholders away from TPR culture and keep the place of rice crop in farming intact.

MATERIALS AND METHODS

A field investigation was carried out during *kharif* (July - November) season of 2015 at Bloomsdale Research Farm of ICAR-Central Island Agricultural Research Institute, Port Blair, Andaman & Nicobar Islands, situated at 11^0 38′ 06" N latitude and 92^0 39′ 15′′ E longitude at an altitude of 14 m-above mean sea level. The experiment was laid out in Split Plot Design (SPD) with two main plot and four sub plot treatments with five replications per treatment. Main plot treatments comprised of two rice establishment methods i.e. transplanted rice (TPR) and direct wet seeded rice (DWSR). The sub-plot treatments include four rice cultivars (3 high yielding varieties i.e. Swarna, BPT-5204, CARI Dhan-6 and a hybrid US-312). A gross sub plot size of 3 m x 6 m (18 m^2) was used in the study. The sub plots were separated by a furrow of 75 cm on all sides in DWSR to drain out water during establishment period. Main plots were separated by 2 m channels on all sides. The experimental soil collected prior to start of experiment during June, 2015 in its top 20 cm depth was analysed as per Jackson (1973) was slightly acidic (6.35 pH), non-saline (ECe: 0.08 dS/m) and contained 247.0-10.9-123 kg/ha of available nitrogen (N) - phosphorus (P) - potassium (K). Main field was prepared by puddling thrice with power tiller in standing water followed by precise levelling to facilitate quick drainage of rain water in DWSR for facilitating successful rice seed germination and seedling establishment. Such a levelled field was partitioned into beds of 3 m width with the two adjacent beds getting separated by a 0.6 m furrow. Rice seeds were soaked in water for 24 hours followed by incubation in gunny bag with frequent watering till start of germination (30 hours time) were uniformly broadcast on the DWSR bed using a seed rate of 20 kg/ha on 30th June. The same seed was also sown in nursery for TPR crop on same day @ 40 kg/ha. The germinated rice seedlings were thinned / readjusted (gap filling) to attain a density of 80 plants/m^2 on 15th day after seeding in DWSR. For first 10 days after seeding, saturation moisture was maintained through giving light irrigations and removing excess water through furrows every alternate day. Standing water was maintained from 11 day onwards and the water level was raised with increase in height of seedlings and 3 cm water depth is maintained from 20th day onwards. In TPR, well grown rice seedlings of 30 days age were transplanted in main field on a well prepared and manually levelled field at 15 cm x 15 cm plant geometry using 2-3 seedlings/hill. Rice crop was uniformly fertilized with 100-26.4-36 kg/ha N-P-K through prilled urea-single super phosphate-muriate of potash. Entire Phosphorus and potassium fertilizers were applied uniformly and incorporated in to the soil in last puddling in both DWSR and TPR. Nitrogen (100 kg/ha) through prilled urea was broadcast applied in 3 splits @ 20, 40 and 40 kg/ha on 10, 35 and 55 days after seeding (DAS) in DWSR and in 3 equal splits on 5, 25 and 45 days after transplanting (DAT) in TPR. First N applications in DWSR coincided with gap filling /thinning cum weeding (15 DAS) and later two applications succeeded the weeding operations in both DWSR and TPR. Rice crop was grown under rain fed conditions (received 1499.3 and 1600 mm rain by DWSR and TPR crop) and was irrigated to maintain a standing water of 3 cm continuously. For weed management, pre-emergence application of pyrazosulfuron ethyl 10 WP @ 25 g a.i/ha and pendimethalin 38.7% CS @ 0.75 kg a.i/ha was done immediately after immediately after seeding (DWSR) and transplanting in TPR, respectively. Three and two manual weedings were done on 10, 35 and 55 DAS of DWSR and 25 and 45 DAT in TPR. Field was dewatered prior to N application and re-watered two days later. Two insecticide / fungicide sprays were given for the protection of crop from sucking pest and fungal diseases.

Field observations on plant height at maturity (5 plants), days to 50% flowering and physiological maturity were recorded treatment wise. Yield attributes (panicles/m^2, number of grains/panicle (10 panicles) and test weight (g) and yield (biological and grain) from net plot were recorded as per standard procedures. Harvest index was arrived as ratio of grain to biological yield. Man power use was recorded and energetics was estimated as per standard procedures. As threshers (diesel or electric operated) are not used by farmers till date, threshing and winnowing operations are done manually, hence has more man power usage for the operation (40-45 man days) in the current study. Economics were worked out using minimum support price of rice grain (Rs. 14700/tonne), assumed price of straw (Rs. 1,500/tonne) and market price of inputs. Benefit Cost ratio was worked out as ratio of gross income (net income + cost of cultivation) to cost of cultivation. The cost of cultivation worked out as Rs. 42,041 for DWSR and as Rs. 52,243 for TPR. The analysis of variance was done in SPD and significance of treatment differences was compared by critical difference at 5% level of significance (P=0.05) and statistical interpretation of treatments was done as per Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Growth and yield attributes

Growth and yields attributes of rice as influenced by establishment methods and cultivar were presented in Table 1. The data showed significant differences in growth (plant height, days to 50% flowering, days to physiological maturity) and yield attributes (number of panicle/m^2, number of grains/panicle and test weight) due to establishment methods and rice varieties tested. Interaction effects were found to be significant for number of panicle/m^2.

DWSR has produced 12.7 cm taller plants than that of TPR (109.6 cm). Taller plants production in DWSR could be ascribed to 1.8 times higher plant density (80/m^2) as compared to TPR (44.4 /m^2). Completion of entire life cycle in main field by DWSR as compared to nursery and main field parts of TPR could also be partially ascribed to taller plants production in DWSR. Among the varieties tested, Swarna being at par with US-312 hybrid has produced significantly taller plants than CARI Dhan-6 and MTU-5204 and further the hybrid has at par plant height as that of later 2 cultivars. CARI Dhan-6 has produced the shortest plants (108.7 cm). Days to 50% flowering and days to maturity were shorter in DWSR by 12.3 and 12.2 days as compared to TPR. The shorter duration of

DWSR was ascribed to absence of transplanting shock and establishment period as encountered by seedlings uprooted from nursery in TPR. The reported shorter duration of DWSR rice crop as compared to TPR reported in the current study is supported by the findings of Jaya Pratiksha *et al.* (2017). Swarna and BPT-5204 cultivars being at par with each have taken longer duration to complete life cycle (12.0-13.5 days) than CARI Dhan-6 and US-312. Crop duration is a genetic characteristic of the variety and the same were reflected in the study.

Among the yield attributes, DWSR has recorded 52.9% higher number of panicles/m^2 than TPR (240.3), however, TPR has 32.95% higher number of grains/panicle than DWSR (103.3) and the test weight did not differ significantly among the two establishment methods. Number of panicles produced / hill was higher in TPR (5.41) than DWSR (4.59). Thus the higher number of panicles/m^2 of DWSR was ascribed to higher plant density. Among the cultivars, MTU-5204 and Swarna recorded significantly higher number of panicles/m^2 and grains / panicle, respectively as compared to other three cultivars. Further Swarna and US-312 hybrid have produced statistically similar number of panicles. CARI Dhan-6 has the lowest number of panicles (225.0). Number of grains/ panicle of BPT-5204, US-312 and CARI Dhan-6 and test weight of Swarna, US-312 and CARI Dhan-6 were statistically at par with each other. MTU-5204 has recorded the lowest test weight (14.59 g) indicating its super fine nature.

Yield and harvest index

Yield (grain and biological) and harvest index varied due to establishment method, cultivar and their interaction effects (Table 2 and Table 3). Among the methods of establishment, DWSR has produced 2.08 and 0.47 t/ha higher biological and grain yield than the TPR (8.68 and 3.81 t/ ha). Taller plants (12.7 cm) and higher number of tillers or panicles produced / unit area (127.2) in DWSR has resulted in 24% higher biological yields (11.76 t/ha) than TPR. Higher number of panicles produced (52.9%) by DWSR more than offsetting the lesser number of grains/ panicle (32.95%) and test weight (1.1%) has resulted in 12.3% higher grain yields than TPR. Significant increases in rice grain yields in drum seeded rice than TPR was reported by Jaya Pratikstha *et al.* (2017) supports the current study results. The harvest index of DWSR was 10.3% lower than TPR (0.439) indicating the poor efficiency of DWSR in converting the higher biomass produced into grain. The low harvest index of DWSR was partially ascribed to its greater lodging on account of taller plants and their asymmetric distribution that resulted in poor root anchoring as compared to TPR that has uniformly spaced seedlings with

Table 1: Effect of establishment methods on growth and yield attributes of rice

Treatment	Plant height (cm) at harvest	Days to first flowering	Days to maturity	Number of panicles/m^2	Grains/ panicle	Test weight (g)
Method of establishment						
DWSR	123.3	87.5	123.8	367.5	103.8	21.06
TPR	109.6	99.8	136.0	240.3	138.0	21.29
SEm ±	1.87	1.77	2.08	6.25	3.67	0.266
CD (P = 0.05)	7.34	6.95	8.17	24.54	14.41	NS
Rice cultivar						
Swarna	126.7	101.5	137.0	293.0	142.1	24.04
BPT-5204	114.5	100.5	135.5	395.1	110.5	14.59
US-312 (hybrid)	117.9	86.5	123.5	302.5	120.0	22.98
CARI Dhan-6	108.7	86.0	123.5	225.0	110.7	24.10
SEm ±	3.20	3.02	3.54	8.54	6.26	0.454
CD (P = 0.05)	9.34	8.82	10.33	24.93	18.27	1.325
Interaction	NS	NS	NS	S	NS	NS

NS: Non-Significant; S: Significant

Table 2: Effect of establishment methods on yield and economics of rice cultivars

Treatment	Yield		Harvest index	Economics (Rs/ha)			Benefit cost Ratio
	Grain (t/ha)	Biological (t/ha)		Cost of cultivation	Gross returns	Net returns	
Method of establishment							
DWSR	4.28	10.76	0.398	42041.0	72636	30595.0	1.73
TPR	3.81	8.68	0.439	52243.8	63312	11068.2	1.21
SEm ±	0.089	0.235	0.0125	-	1112.2	700.0	-
CD (P = 0.05)	0.349	0.923	0.0491		4366.5	2748.2	-
Rice cultivar							
Swarna	4.53	11.62	0.390	46473.4	77226	30752.6	1.66
BPT-5204	4.03	9.56	0.422	46473.4	67536	21062.6	1.45
US-312 (hybrid)	4.20	9.35	0.449	49149.0	69465	20316.0	1.41
CARI Dhan-6	3.42	8.34	0.410	46473.4	57654	11180.6	1.24
SEm ±	0.121	0.400	0.0210	-	1501.5	946.1	-
CD (P = 0.05)	0.353	1.170	0.0613	-	4382.9	2761.7	-
Interaction	S	S	S	-	S	S	-

S: Significant

Table 4: Input use efficiency indices of rice cultivars under two establishment methods

Treatment	Rain fall capture (mm)	Rain water productivity (kg grain/mm rain water)	Energy input (MJ)	Energy output(MJ)	Energy productivity (MJ output/ MJ input)	Factor productivity of fertilizers (kg grain/kg NPK used)	Per day productivity (kg grain/ day)
Method of establishment							
DWSR	1513.1	2.83	14560.3	148376	10.19	26.35	34.55
TPR	1586.9	2.40	15731.0	121436	7.72	23.46	28.01
SEm ±	-	0.042	-	-	-	-	-
CD (P = 0.05)	-	0.165	-	-	-	-	-
Rice cultivar							
Swarna	1600.6	2.83	15145.7	160888	10.62	27.89	33.07
BPT-5204	1590.6	2.53	15145.7	132790	8.77	24.82	29.69
US-312	1504.4	2.79	15145.7	130235	8.60	25.86	34.01
CARI Dhan-6	1504.4	2.27	15145.7	115710	7.64	21.06	27.69
SEm ±	-	0.061					
CD (P = 0.05)	-	0.178					

Table 3: Interaction effect of establishment methods and rice cultivars on grain yield (t/ha)

Rice cultivar	Establishment method	
	DWSR	TPR
Swarna	4.30	4.76
BPT-5204	3.70	4.36
US-312(hybrid)	4.09	4.31
CARI Dhan-6	3.15	3.69
SEm ±	0.132	
CD (P = 0.05)	0.385	

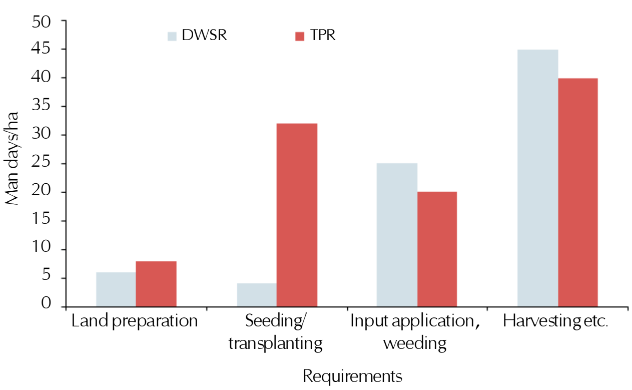

Figure 1: Effect of rice establishment methods on manpower requirement (man days/ha)

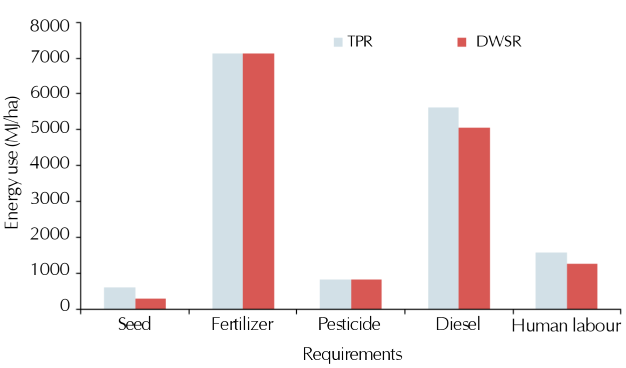

Figure 2: Energy use (MJ/ha) of rice under two establishment methods

better root anchoring. Among the cultivars, Swarna (4.53 t/ha) recorded 7.86, 12.41 and 33.0% higher grain yield than US-312, BPT-5204 and CARI Dhan-6, respectively. Higher number of panicles of Swarna over CARI Dhan-6 and higher number of grains /panicle than other three cultivars and higher test weight than BPT-5204 together have brought above grain yield superiority to Swarna cultivar. Further, BPT-5204 and US-312 being at par with each other have recorded 17.8 and 22.8% higher grain yield than CARI Dhan-6. Despite of producing the highest number of panicles (395.1), BPT-5204 could not produce higher grain yields on account of its least test weight (14.59 g) and thus relegated to third position in terms of productivity among the cultivars tested. Differential yields of varieties of the current study are in conformity with the findings of Kaur *et al.* (2016). Interaction effect of establishment methods and rice cultivars on grain yield (Table 3) indicates that US-312 hybrid has statistically similar performance under both the establishment methods while other three cultivars have recorded significantly better performance under DWSR. The higher grain yield of cultivars under DWSR was ascribed to higher number of panicles.

Economics

Cost of cultivation (Rs. /ha) of DWSR was 10, 202 lower than TPR. The higher grain (0.47 t/ha) and straw yields (1.61 t/ha) of DWSR as compared to TPR has added Rs. 9,324 to the net income. In total, DWSR has Rs.19, 526/ha higher income than TPR (Rs. 11, 068). The Benefit Cost ratio of DWSR was also 0.52 units higher than TPR (1.21). Lower man power used in DWSR (20%) due to avoidance of nursery and transplanting operations was main contributor to the reduced cost of cultivation over TPR. Among the cultivars, Swarna has the highest net income (Rs. 30,752/ha) while CARI Dhan-6 has the lowest income (Rs.11, 180 /ha). BPT-5204 and US-312 (hybrid) have identical net incomes. The B: C ratio followed the trend of net income. Interaction effects were not significant. In the estimation of economics, common price was used for both super fine variety BPT-5204 and medium slender grain types of other 3 cultivars. BPT-5204 variety will become more economical, if its premium price commanded was used.

Input use efficiency

DWSR (Table 4) captured 73.3 mm less rainfall from July-

October than TPR (1586.9 mm). Rain water productivity (kg grain/mm) of DWSR was 17.92% higher than TPR (2.40). Among the cultivars, US-312 and CARI Dhan-6 with short duration has captured less rain water (1504.4 mm) than Swarna and BPT-5204 (1600.6 and 1590.6 mm) that have 2 weeks more crop duration. Similar increases in water productivity of DWSR were reported by Dawe (2005). However on account of higher grain yield, Swarna being at par with US-312 stood at the top in terms of rain water productivity. CARI Dhan-6 has least rain water productivity.

DWSR has reduced the man power input by 20 man days (20%) as compared to TPR (100 man days). This reduction in man days in DWSR came mainly from the avoidance of nursery (2 days) and transplanting operations (28 man days) associated with TPR (Fig 1). However, DWSR required 5 additional man days/ha for thinning, gap filling cum weeding at 15 DAS and another 5 additional man days for harvest, threshing and cleaning operations of lodged crop with higher yields. A similar reduction in man power requirement of DWSR as compared to TPR was reported by Jaya Pratiksha *et al.* (2017). The energetics estimated (Fig 2) as per Patel *et al.* (1994) and presented in Table 4 indicates that DWSR required 1170.7 MJ less energy input than TPR (15731 MJ/ha). However, the energy output of DWSR was 26490 MJ higher than TPR (121436 MJ/ ha). Energy productivity of DWSR was 2.47 units higher than TPR (10.19). Similar advantages in energy productivity with direct seeding were reported by Bhardwaj *et al.* (2016). Energy output and energy productivity of cultivars following the trend of yields were highest in Swarna and least with CARI Dhan-6.

Factor productivity of fertilizers applied i.e. 162.4 kg/ha NPK (kg grain/kg fertilizer applied) and per day productivity (kg grain/ day) of DWSR was 12.1 and 23.4% higher than TPR (23.46 and 28.01). Higher factor productivity of DWSR was ascribed to 0.47 t/ha higher grain yield than TPR while quantity of fertilizer applied was same in both the methods of establishment. The higher per day productivity was ascribed to both higher yield and shorter duration (12.2 days). Factor productivity of fertilizers and per day productivity of rice crop was highest in Swarna and US-312 on account of higher grain yield and shorter duration, respectively.

From the study, it is concluded that direct wet seeding of rice was most promising and alternate solution to less profitable and loss making transplanted culture. Swarna is the most promising cultivar for the Islands. However, Andaman & Nicobar Islands rice growing regions during June and July months experience prolonged rains (about 20 rainy days with rainfall ranging from 469-627 mm). Under such scenario, the broadcast seeds in DWSR are most likely to get displaced or even washed away. Suitable coping mechanism needs to be evolved for this exigency. Dry seeding of rice in start of rainy season in the month of May or parachute technology could come handy and needs evaluation.

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